VERIFICATION OF TRANSLATION

I, Shiho Watanabe, translator of 6F Yodagawa 5-Bankan, 3-2-1, Toyosaki, Kita-ku, Osaka, Japan, hereby declare that I am conversant with the English and Japanese languages and am a competent translator thereof. I further declare that to the best of my knowledge and belief the following is a true and correct translation made by me of Japanese Patent Application No. 2002-296226 filed on October 9, 2002.

Date: July 22, 2008

渡辺 史帆

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[DOCUMENT] Patent Application

[OUR REFERENCE NO.] 2036440146

[FILING DATE OF APPLICATION] October 9, 2002

[To] Commissioner, Patent Office

[INTERNATIONAL PATENT CLASSIFICATION] G09G 3/28

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[AMOUNT] 21,000 yen

[LIST OF ENCLOSURES]

Specification 1

Drawings 1

Abstract 1

[POWER OF ATTORNEY NO.] 9809938

[DOCUMENT] Specification

[TITLE OF THE INVENTION] PHOSPHOR AND PHOSPHOR TREATMENT METHOD

[CLAIMS]

[Claim 1]

A phosphor treatment method comprising:

a first step of forming reactive gas atmosphere by performing an excitation on gas into a certain reactive state, the gas including at least one of inert gas, rare gas and reactive gas; and

a second step of impregnating a phosphor with the reactive gas atmosphere.

[Claim 2]

The phosphor treatment method of Claim 1, wherein

the reactive gas atmosphere is atmospheric pressure or pressure close to atmospheric pressure.

[Claim 3]

The phosphor treatment method of one of Claims 1 and 2, wherein

the reactive state is a plasma state.

[Claim 4]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

a location in which the first step is performed is separated from a location in which the second step is performed.

[Claim 5]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

the reactive gas includes fluorine atoms.

[Claim 6]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

the treatment method is altered for each of a plurality of kinds of phosphors.

[Claim 7]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

the reactive gas includes atoms composing a crystal structure of a phosphor to be treated.

[Claim 8]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

the phosphor is heated.

[Claim 9]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

an electric field is applied to the phosphor.

[Claim 10]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

the first step includes a sub step of heating the gas.

[Claim 11]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

the gas which has been brought into the reactive state is

ejected from a reactor vessel by pressure at which the gas is introduced.

[Claim 12]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

the phosphor has a structure in which a constituent element ratio of a surface of the phosphor and a vicinity of the surface is different from a constituent element ratio of the phosphor except for the surface of the phosphor and the vicinity of the surface.

[Claim 13]

The phosphor treatment method of one of Claims 1, 2 and 3, wherein

the phosphor is structured to have a part, on and in a vicinity of a surface of the phosphor, containing an element different from one of a constituent element and an additive element contained in the phosphor except for the surface of the phosphor and the vicinity the surface.

[Claim 14]

A phosphor treatment apparatus comprising:

a first treatment unit operable to form reactive gas atmosphere by performing an excitation on gas into a certain reactive state, the gas including at least one of inert gas, rare gas and reactive gas; and

a second treatment operable to impregnate a phosphor with the reactive gas atmosphere.

[Claim 15]

The phosphor treatment apparatus of Claim 14, wherein

the reactive gas atmosphere is atmospheric pressure or pressure close to atmospheric pressure.

[Claim 16]

The phosphor treatment apparatus of one of Claims 14 and 15, including a unit that applies a high-voltage electric field, wherein

the reactive state is a plasma state.

[Claim 17]

The phosphor treatment apparatus of one of Claims 14, 15 and 16, wherein

the phosphor is unaffected by the excitation performed in the first treatment unit.

[Claim 18]

The phosphor treatment apparatus of one of Claims 14, 15 and 16, wherein

the reactive gas includes fluorine atoms.

[Claim 19]

The phosphor treatment apparatus of one of Claims 14, 15 16 and 17, including a heat device for heating the phosphor.

[Claim 20]

The phosphor treatment apparatus of one of Claims 14, 15 and 16, including a device for applying an electric field to the phosphor.

[Claim 21]

The phosphor treatment apparatus of one of Claims 15, 16 and 17, including a device for heating the gas to be introduced to the first treatment unit.

[Claim 22]

The phosphor treatment apparatus of one of Claims 14, 15 and 16, wherein

the gas which has been brought into the reactive state is ejected from the first treatment method by pressure at which the gas is introduced.

[Claim 23]

A phosphor has a structure in which a constituent element ratio of a surface of the phosphor and a vicinity of the phosphor is different from a constituent element ratio of the phosphor except for the surface of the phosphor and the vicinity of the surface.

[Claim 24]

A phosphor is structured to have a part, on and in a vicinity of a surface of the phosphor, containing an element different from one of a constituent element and an additive element contained in the phosphor except for the surface of the phosphor and in the vicinity of the surface.

[Claim 25]

An image display apparatus using the phosphor of one of Claims 23 and 24.

[Claim 26]

A plasma display apparatus using the phosphor of one of Claims 23 and 24.

[Claim 27]

An illumination device using the phosphor of one of Claims 23 and 24.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

The present invention relates to phosphors used for plasma display panels (PDP) used for displays or the like of color TV receivers.

[0002]

[DESCRIPTION OF THE RELATED ART]

An AC-driven surface discharge PDP having a three-electrode structure is known as a PDP suitable for a full color display using three color phosphors.

[0003]

FIG.4 is a schematic cross-sectional diagram showing a structure of a conventional PDP. In the present diagram, formed on the front glass substrate 1 are display electrodes 2 that are covered by a dielectric glass layer 3 and a magnesium oxide (MgO) dielectric protective layer 4 (see, for example, Patent Reference 1).

[0004]

On the rear glass substrate 5, on the other hand, address electrodes 6 and barrier ribs 7 are disposed, and phosphor layers 9-11 of respective colors (red, green, and blue) are each provided in the space between two adjacent barrier ribs 7.

[0005]

The front glass substrate 1 as formed above is disposed on the barrier ribs 7 arranged on the rear glass substrate 5, and discharge gas is filled between these substrates 1 and 5 to form a discharge space 8.

[0006]

In this PDP, vacuum ultraviolet light (predominantly, a wavelength of 147 nm) is generated through an electric discharge, and the phosphor layers 9-11 of three colors are excited to thereby emit light, which results in a display in colors.

[0007]

The above PDP can be manufactured as follows.

[0008]

A silver paste is applied to the front glass substrate 1, and then fired to form the display electrodes 2. Further, a dielectric glass paste is applied over the display electrodes 2, and then fired to form a dielectric glass layer 3, on which a protective layer 4 is formed.

[0009]

Onto the rear glass substrate 5, on the other hand, a silver paste is applied and fired to form the address electrodes 6. Next, a glass paste is applied at predetermined intervals, and then fired to form the barrier ribs 7. Subsequently, the phosphor layers 9-11 are formed by respectively applying phosphor pastes of individual colors to the spaces between the barrier ribs 7, and firing the phosphor pastes at around 500 °C to remove resin components and the like therefrom. After this firing process for forming the phosphor layers 9-11, sealing glass frits are applied around the edge of the rear glass substrate 5 to herewith form a sealing glass layer, and calcinated at around 350 °C in order to remove resin components and such from the formed sealing glass layer (frit calcination process).

[0010]

Then, the front glass substrate 1 and the rear glass substrate 5 are laid on top of each other so that the display electrodes 2 and the address electrodes 6 face at right angles to one another. These superimposed glass substrates are attached and sealed by heating at a temperature (approximately 450 °C) higher than the softening temperature of the sealing glass (sealing process).

[0011]

Subsequently, as the sealed panel formed of the front and rear glass substrates 1 and 5 is heated up to around 350 °C, air is evacuated from the internal space formed between the both glass substrates, i.e. the space which is formed between the front and rear glass substrates 1 and 5, and to which the phosphor layers are exposed (evacuation process). After the evacuation process is completed, discharge gas is introduced to the space until the pressure reaches a predetermined point (normally, 39.9 kPa - 66.5 kPa, or 300 Torr - 500 Torr).

[0012]

In such PDP, how to improve the luminescent characteristics, including improvement in luminance has become important. In particular, it is sometimes the case that the quality assurance period of a PDP is determined based on time-lapse changes in luminescent characteristics of the phosphors used for a luminous display unit of the PDP.

[0013]

In order to suppress deterioration, a method of covering a surface of each phosphor with a protective coat is adopted. This

method, however, becomes a factor of cost increase since a process of covering each of the phosphors is added.

[0014]

Patent Document 1: Japanese published unexamined application No. H8-31325

[0015]

[PROBLEM TO BE SOLVED BY THE INVENTION]

There has been a big challenge to obtain a phosphor having smaller time-lapse changes during a PDP manufacturing process and during the time when the PDP is in operation. Due to moisture, application of heat or the like in the PDP manufacturing process, the luminance of phosphors deteriorates and the chromaticity of the phosphors also changes. Therefore, the time-lapse changes in phosphors during the PDP manufacturing process leads to degradation in characteristics of panels. In addition, the phosphor layers are exposed to plasma associated with an electric discharge during the time when the PDP is in operation, which results in further changes in phosphor layers over time.

[0016]

Possible factors of time-lapse changes are as follows:

i) moisture adsorption to the surface of the phosphor;

ii) defects in the phosphor crystal structure;

iii) substances other than the phosphor crystals mixed in;

iv) change in crystal structure due to heat application to the phosphor; and

v) destruction of the crystal structure caused by exposing the phosphor to plasma associated with an electric

discharge.

[0017]

The present invention has an object to suppress time-lapse changes in luminescent characteristics of phosphors which are mainly arisen, among the factors above, from the factor *ii)* (defects in the phosphor crystal structure), and an object to manufacture a PDP having an excellent luminescent characteristic.

[0018]

[MEANS TO SOLVE THE PROBLEMS]

In order to solve the above-stated problems, the phosphor treatment method pertaining to the present invention modifies a surface of each phosphor, and eliminates factors of time-lapse changes.

[0019]

The invention of Claim 1 or 2 is a phosphor and a phosphor treatment method having the first object to suppress time-lapse changes. In order to achieve this object, a constituent element ratio of a surface of the phosphor and a region in a vicinity of the surface is made different from a constituent element ratio of a region of the phosphor except for the surface of the phosphor and vicinity of the surface by impregnating, with the phosphor, gas which has been brought into a reactive state by applying energy, and a crystallinity of the phosphor is improved.

[0020]

For example, moisture adsorption to the surface of the phosphor and a change in a crystal structure which become the factors of time-lapse changes are often caused by defects in a phosphor

crystal. Therefore, it is possible to compensate the defects and suppress the time-lapse changes by including, in introduced gas, an atom that compensates the defects in the phosphor crystal.

[0021]

Also, it is possible to modify the surface of the phosphor and the vicinity of the surface, and to suppress the time-lapse changes by including, in the introduce gas, an atom that becomes a protective coat that eliminates factors of deterioration. For example, it is possible to suppress the time-lapse changes by covering a layer that functions as a protective layer having water repellency on and in a vicinity of the phosphor surface by including, in the introduced gas, an atom of fluorine or the like.

[0022]

As to these advantages, since a wide variety of atoms can be used for the introduced gas, it is possible to eliminate many factors of deterioration, and it is possible, at the same time, to eliminate some factors of deterioration. Also, a treatment process is performed at atmospheric pressure, which results in a high throughput of the treatment process. Furthermore, since the present invention is realized by exposing the phosphors to the introduced gas, the treatment process is simple and the present invention can be used in a wide range of treatment processes.

[0023]

The inventions of Claim 3 are a phosphor and a phosphor treatment method that bring introduced gas into a reactive state by converting the introduced gas into plasma. It is possible to suppress a plasma damage to a phosphor by including, in inert gas,

discharge gas and gas lower in electron mobility than discharge gas.

[0024]

The invention of Claim 4 can suppress the plasma damage to the phosphor by exciting introduced gas at a location separated from the phosphor.

[0025]

In the invention of Claim 5, introduced gas including fluorine atoms is used, and a protective layer having water repellency covers the surface of the phosphor and or a vicinity of the surface in order to suppress the deterioration due to moisture of the phosphor. Thus, it is possible to suppress a moisture adsorption which is a big factor of time-lapse changes.

[0026]

The invention of Claim 6 alters treatment parameters such as types of the introduced gas and the like for each of many kinds of phosphors used in an illumination device or an image display apparatus. This makes it possible to conduct a treatment appropriate to cope with degradation factors of each phosphor, making it possible to suppress the time-lapse changes of the image display apparatus. Also, it is possible to realize an image display apparatus that emits more balanced light by changing the degree of the treatment.

[0027]

The invention of Claim 7 compensates defects in a phosphor crystal, and modifies the surface of the phosphor to have good crystallinity by using gas including atoms included in the crystal structure of a phosphor as introduced gas, thereby suppressing the

time-lapse changes. Especially when the phosphor is composed of an oxide, it is possible to compensate oxygen vacancies in the phosphor crystal and to modify the surface of the phosphor to have good crystallinity by including oxygen atoms in reactive gas. This makes it possible to eliminate deterioration factors caused by oxygen vacancies and to realize a phosphor particle having small time-lapse changes.

[0028]

In order to accelerate the reaction between the phosphor and the reactive gas more, the invention of Claim 8 heats, when performing the phosphor treatment, the phosphor during the treatment, or before or after the treatment. This accelerates the reaction between the phosphor and the reactive gas, enhancing the effect of the treatment.

[0029]

The invention of Claim 9 has an object to increase, when performing a phosphor treatment, an amount of gas in a reactive state by applying voltage to the phosphor and performing the treatment. Here, the gas impregnates the surface of a phosphor and a vicinity of the surface of the phosphor. Also, it is possible to enhance the effect of the treatment by keeping the reactive gas with which the phosphor has once been impregnated in the surface of the phosphor and the vicinity of the surface.

[0030]

In order to accelerate the reaction more, the invention of Claim 10 heats, when performing the phosphor treatment, the reactive gas. This accelerates the reaction between the phosphor and the reactive gas, enhancing the effect of the treatment.

[0031]

The invention of Claim 25 can realize an image display apparatus having smaller time-lapse changes by using at least one kind of phosphor manufactured using the phosphor treatment method pertaining to the present invention.

[0032]

The invention of Claim 26 is a PDP in which at least one kind of phosphor manufactured using the phosphor treatment method pertaining to the present invention is used. Since the deterioration in phosphor is a major challenge for a display compared to other image display apparatuses, it is possible to realize a PDP having an excellent quality by the treatment. Also, a phosphor excitation wavelength of a PDP is mainly 147 nm, which is in the range of the vacuum ultraviolet. Therefore, the vacuum ultraviolet light is absorbed on or in a vicinity of the surface of the phosphor, and light is emitted on or in a vicinity of the surface. A region of the phosphor to be modified pertaining to the present invention is only a phosphor surface region, which is very effective for a phosphor used in a PDP.

[0033]

The invention of Claim 27 can suppress time-lapse changes in an illumination device by using at least one kind of phosphors manufactured using the phosphor treatment method pertaining to the present invention in an illumination device in which a phosphor is used.

[0034]

[EMBODIMENTS OF THE INVENTION]

First embodiment

A description is given of a first embodiment of the PDP pertaining to the present invention. Since an overall structure of the PDP is the same as a conventional structure shown in FIG.1, the description of the structure is omitted. Also, an outline of the manufacturing method of the PDP pertaining to the present invention is the same as a conventional manufacturing method, and a description of the method is omitted.

[0035]

Phosphor treatment method and treatment apparatus

The present invention is characterized by a phosphor and a phosphor treatment method. The following describes this phosphor and this phosphor treatment method.

[0036]

FIG.1 shows a structure of the phosphor treatment apparatus used in the phosphor treatment method in the embodiment of the present invention.

[0037]

Firstly, a description is given of a structure of the phosphor treatment apparatus used in the phosphor treatment method of the present invention using FIG.1. In FIG.1, 18 is a gas inlet used for introducing introduced gas 14, 19 is a gas outlet used for discharging excited gas, 17 is a reactor vessel used for reacting the introduced gas 14, 21 is a high-frequency power source that applies an electric field to a high-voltage electrode 16 and an earth electrode 15, and 24 is a mobile stage on which a processing object 22 to which a phosphor 23 is attached is placed. The introduced

gas 14 is a mixed gas of He which is rare gas used for discharge and Ar which is inert gas for mitigating a plasma damage. Pressure is preferably in the range of 1 kPa to 10 Mpa which is close to atmospheric pressure, and more preferably in the range of 10 kPa to 110 kPa. The reactor vessel 17 is made of a dielectric material, and is structured to be insulated from the earth electrode 15 and the high-voltage electrode 16. In FIG.1 of the apparatus, a quartz tube is used.

[0038]

Next, a description is given of movements of the phosphor treatment apparatus used in the phosphor treatment method of the present invention.

[0039]

The introduced gas 14 is introduced into the reactor vessel 17, and is brought into the reactive state. Then the introduced gas 14 in the reactive state is flown out to the phosphor from the gas outlet 19. In the reactor vessel 4, the introduced gas 14 is converted into plasma 20 by applying a high-frequency electric field to the high-voltage electrode 16 and the earth electrode 15 using the high-frequency power source 21. It is preferable that applied voltage is set in the range of 10 V to 10000 V while the frequency is set in the range of several kilohertz (kHz) to several tens of gigahertz (GHz). A plasma process is performed on the phosphor by discharging the introduced gas 14 that has been converted into the plasma to a phosphor 23 from the gas outlet 19. At this time, the stage 24 on which the processing object is mounted moves so as to arbitrarily scan the surface of the phosphor layer. This makes it possible to

process a large surface area evenly in a short period of time. Note that the depths of modification is arbitrarily set according to the speed of the scan.

[0040]

A surface of the phosphor 23 is modified by impregnating the phosphor 23 with the reactive gas which has been activated. That is, the reactive gas which has been brought into the reactive state (i) reacts with impurity substances or the like on and around the surface of the phosphor due to a radical reaction or the like, and (ii) eliminates factors that accelerate the time-lapse changes. For example, when oxygen (O_2) is used as reactive gas, carbon atoms that exist on and around the surface are combined with oxygen atoms that have been brought into the reactive state to form carbon dioxide. This makes it possible to exclude the carbon atoms from the surface of the phosphor and the periphery of the phosphor surface.

[0041]

As mentioned above, by adopting a structure in which the introduced gas 14 is introduced into the reactor vessel 17, is brought into the reactive state, and is flown out to the phosphor from the outlet 19 in the reactive state, the high frequency voltage is not directly applied to the phosphor, and the phosphor is not exposed to the plasma discharge space. Therefore, it is possible to reduce the plasma damage.

[0042]

Here, the introduced gas 14 is composed of rare gas for generating discharge gas, inert gas and reactive gas having an effect that eliminates deterioration factors. Also, halogen atoms, chalcogen

atoms or the like are mainly used as the reactive gas. However, the composition of the introduced gas 14 is not limited to this. Also, the introduced gas does not have to include the inert gas, and the rare gas alone can be used as the introduced gas 14.

[0043]

As mentioned above, the mixed gas of He which is rare gas used for discharge and Ar which is inert gas for mitigating the plasma damage is used as the introduced gas 14 in the present embodiment. By using the inert gas which is lower in electron mobility than gas used for discharge, it is possible to reduce the plasma damage. Also, when the reactive gas is lower in electron mobility than the gas used for discharge, the inert gas does not have to be used.

[0044]

Also, all of the compositions of the introduced gas 14 do not have to be in gaseous forms at ambient temperatures, and a method of supplying is selected depending on states of the compositions of the introduced gas 14 (solid, liquid or gas) at discharge-region temperature or at ambient temperatures. That is, when the compositions of the introduced gas are in the gaseous form at discharge region temperature or at ambient temperatures, the compositions can be used as they are. When the compositions of the introduced gas 14 are in the liquid form, the compositions can be used as vapor, the liquid can be bubbled using the inert gas or the like and flown in, or the liquid can be applied on the surface of a non processing object. Also, when the compositions of the introduced gas are not in the gaseous form and have a comparatively low vapor pressure, the compositions of the introduced gas can be

used after being heated so as to be in a high vapor pressure state. In this case, the temperature for heating is preferably in the range of 50 °C to 600 °C.

[0045]

Phosphor manufactured using the phosphor treatment method of the present invention

A description is given of a phosphor manufactured using the phosphor treatment method of the present invention using FIG.2. FIG.2 shows the structure of the phosphor manufactured using the phosphor treatment method of the present invention. The phosphor of the present invention is composed of (i) a modified portion 12 which is a portion including a surface of the phosphor and a vicinity of the surface having a constituent element ratio that is different from a constituent element ratio of the phosphor except for the surface of the phosphor including a vicinity of the surface, and (ii) an internal portion 13 which is a part of the phosphor except for the surface of the phosphor including a vicinity of the surface. This is because modification and coating of the present invention are performed on a part including the surface of the phosphor and the vicinity of the surface of the phosphor. Here, the surface of the phosphor and the vicinity of the surface are impregnated with the introduced gas. A thickness of the modified portion is 1 nm to 1 μm, and more preferably 2 nm to 100 nm.

[0046]

A region of the phosphor to be modified necessary for suppressing the time-lapse changes is only a light-emitting region of the phosphor. An excitation region of the phosphor is different depending

on energy to be excited. Especially in a PDP, since the phosphor is mainly excited by vacuum ultraviolet light, only a part including the surface of the phosphor and the vicinity of the surface is excited. This surface and this part are up to tens of nanometers deep from the surface.

[0047]

Since a surface part of the phosphor is mainly modified in the phosphor treatment method of the present invention, the phosphor treatment method of the present invention is very effective for a phosphor used in a PDP whose light-emitting region is a phosphor surface. Note that since the light-emitting region changes in a vicinity of the phosphor surface by the time-lapse changes, it is preferable that a region part to be modified is large.

[0048]

For example, BAM which is a blue phosphor material generally used in the PDP is a luminescent center Europium (Eu), and BAM is combined in an oxide reduction atmosphere in order to prevent the oxidization of this Eu. Therefore, many oxygen vacancies exist in crystals of the BAM. These oxygen vacancies often become a factor of the time-lapse changes. Especially, when the oxygen vacancies absorb moisture, the chromaticity of the luminescent characteristic of the BAM changes. Also, degradation of luminance during an operation is accelerated due to the moisture absorption. Furthermore, when the phosphor comes in contact with the moisture, moisture enters an inner part of a finished panel, which affects the operation of a PDP. Therefore, BAM having a few oxygen vacancies is desired for a phosphor used for the PDP.

[0049]

In view of the above problem, in the phosphor treatment method of the present invention, oxygen brought into the reactive state is chemically reacted with the phosphor, and oxygen vacancies on the surface layer of BAM are compensated by using gas including oxygen atoms as introduced gas, making it possible to realize BAM having small time-lapse changes. In order to bring the introduced gas into a reactive state, the oxide atoms are brought into a reactive state by applying a high-frequency electric field to the introduced gas and converting the introduced gas into plasma. A chemical reaction is caused between such oxygen brought into the reactive state and the phosphor, which modifies the phosphor.

[0050]

Also, a modified portion 12 is covered with fluorine compound layer having water repellency by using introduced gas including fluorine atoms. Such fluorine compound layer suppresses moisture absorption, which can suppress the time-lapse changes of BAM. It is preferable to set the fluorinated gas in the range of 0.1% to 10%. Also, the oxygen brought into the reactive state is effective in eliminating impurities that exist on and in a vicinity of the surface, and impurities produced when the phosphor was synthesized. Here, the impurities that exist on and in the vicinity of the surface are included during the process of applying the phosphor.

[0051]

Effects of the phosphor treatment method of he present invention

FIG.3 is a characteristic graph showing a chromaticity of the phosphor treated by the phosphor treatment method pertaining to

the embodiment of the present invention. It can be seen that deterioration in chromaticity becomes smaller as the number of phosphor treatments increases.

[0052]

Modification

The following describes modifications pertaining to the phosphor treatment method and the treatment apparatus of the present invention. Although the phosphor treatment apparatus of the present embodiment has the structure in which the phosphor 23 is placed on the processing object 22, the processing object can be composed of only a phosphor without a substrate. That is, the phosphor 23 may be placed on the processing object 22 in a powder form, or may be in a phosphor layer state in which the phosphor is applied on the processing object 22. Also, the phosphor 23 may be directly placed on the stage 24 without being placed on the processing object.

[0053]

Also, in order to perform the treatment of the present invention on a large surface area evenly, the stage 24 on which the processing object is mounted moves so as to arbitrarily scan on the phosphor surface. However, in addition to moving the stage, the processing object 22 may be fixed and the reactor vessel 17 may move, or the stage and the reactor vessel may move together.

[0054]

Also, the depth of modification may be arbitrarily determined by speed of the scan. However, this can be determined by the number of scans. It is desirable that each depth of modification and an absorbing coefficient of excitation light to be used is in the range

in which a region to be excited to emit light is sufficiently modified.

[0055]

Note that the depths of modification and an amount of coverage can be determined by a ratio between inert gas and reactive gas, the voltage of the high frequency electric field or frequency. For example, when a ratio of the reactive gas is increased, modification accelerates. Also, when a ratio of the reactive gas is low, not only the effect of the modification is small, but also plasma damage increases as shown above, deteriorating the phosphor. By combining the above, it is possible to determine how deep the phosphor particle is modified or covered appropriately.

[0056]

Also, a mechanism may be provided that accelerates the reaction between the introduced gas brought into the reactive state and the phosphor. For example, it is possible to accelerate the reaction with the introduced gas in the reactive state by heating the phosphor in the range of 100 °C to 600 °C during the treatment. This effect can be obtained even if the phosphor is heated before or after the treatment. Also, an electric field may be applied near the processing object in order to bring the introduced gas which has been brought into in the reactive state closer to the surface of the phosphor.

[0057]

Also, a treatment may be performed for each of the regions of three colors of phosphors which are separated from one another. Several kinds of phosphors exist in a processing object depending on the application of the phosphor. For example, at least a phosphor glows in red, a phosphor glows in blue and a phosphor glows in green

exist in a tricolor fluorescent lamp or the like for an image display apparatus and an illumination device. In the case of the image display apparatus, phosphors of three colors (red, blue and green) exist separated from one another. Therefore, it is possible to perform a treatment for each of the regions of three colors of phosphors which are separated from one another. In order to perform treatment in such way, an outlet 5 of the reactor vessel may be formed into a narrow tubular structure or a narrow comb-like structure.

[0058]

Also, at least the phosphors of three colors exist together in a tricolor fluorescent lamp. Therefore, the treatment that eliminates factors that cause the time-lapse changes of the phosphors of three colors may be performed a plurality of times.

[0059]

[EFFECTS OF THE INVENTION]

The present invention is capable of suppressing the time-lapse changes in luminescent characteristics of the phosphors, and is capable of manufacturing a PDP having excellent luminescent characteristics.

[BRIEF DESCRIPTION OF THE DRAWINGS]

FIG.1 is a structural diagram of an apparatus pertaining to the present invention that coverts an introduced gas into plasma under atmospheric pressure, and performs a phosphor treatment with the resultant gas.

FIG.2 is a sketch of the phosphor of the present invention.

FIG.3 is a characteristic graph showing the result of the treatment of the present invention.

FIG.4 is a sectional view of a general PDP panel.

[DESCRIPTION OF CHARACTERS]

1 front glass substrate

2 display electrode

3 dielectric glass layer

4 dielectric protective layer

5 rear glass substrate

6 address electrodes

7 barrier ribs

8 discharge space

9 red phosphor layer

10 green phosphor layer

11 blue phosphor layer

12 modified portion

13 internal portion

14 introduced gas

15 earth electrode

16 high voltage electrode

17 reactor vessel

18 gas inlet

19 gas outlet

20 plasma

21 high-frequency power source

22 processing object

23 phosphor

24 stage

[DOCUMENT] Abstract

[ABSTRACT]

[PROBLEM]

The present invention provides a PDP that is capable of suppressing the time-lapse changes in luminescent characteristics of the phosphors caused by defects of a crystal structure, and has excellent luminescent characteristics.

[MEANS TO SOLVE THE PROBLEM]

By performing a phosphor treatment in which a gas which has been brought into a reactive state by converting introduced gas into plasma is impregnated with a phosphor, a constituent element ratio of the surface region of the phosphor and the vicinity of the surface region is made different from a constituent element ratio of a region of the phosphor except for the surface region of the phosphor and the vicinity of the surface region, the crystallinity of the phosphor is enhanced, and time-lapse changes of the phosphor are suppressed.

[SELECTED FIGURE] FIG.1

[DOCUMENT]: Drawings

FIG. 1

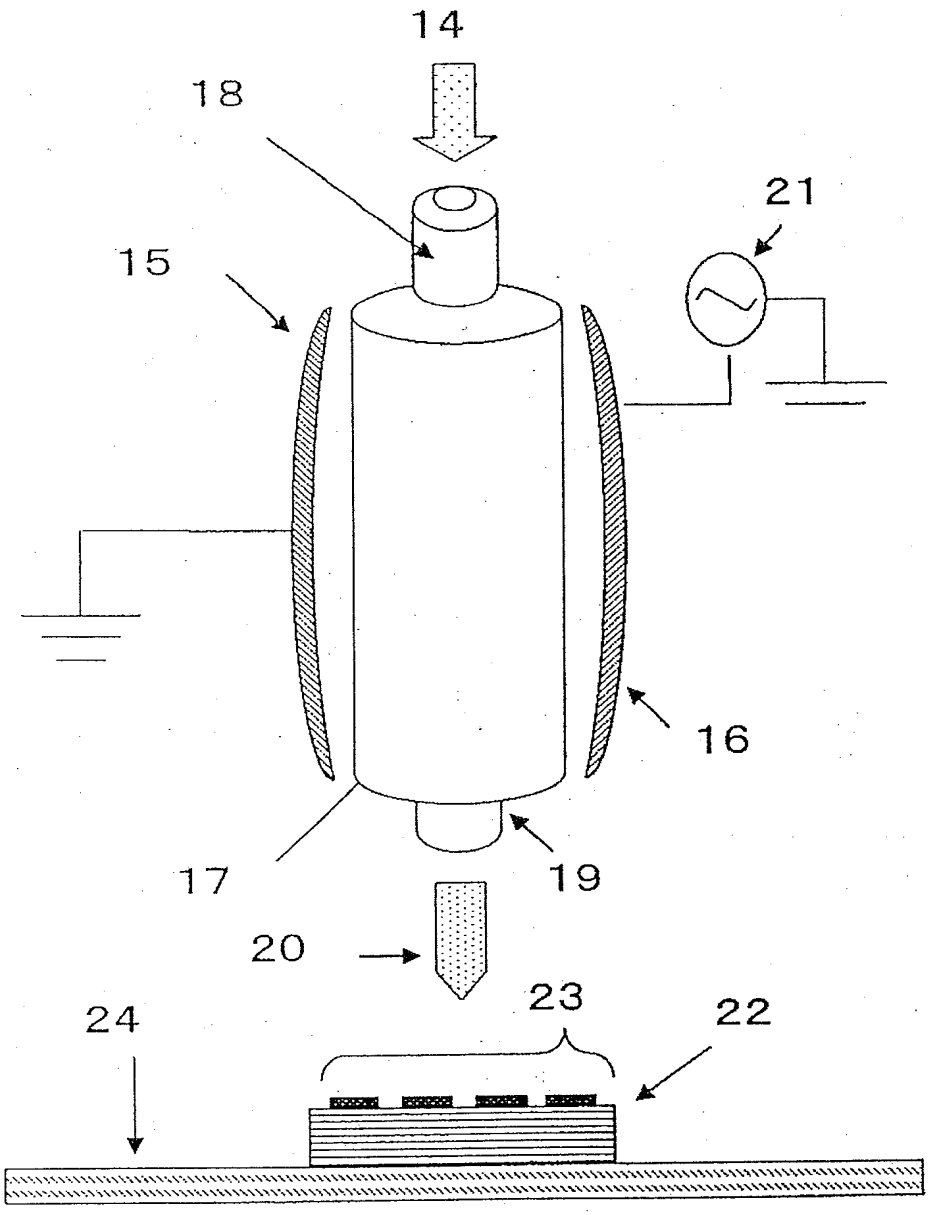

FIG. 2

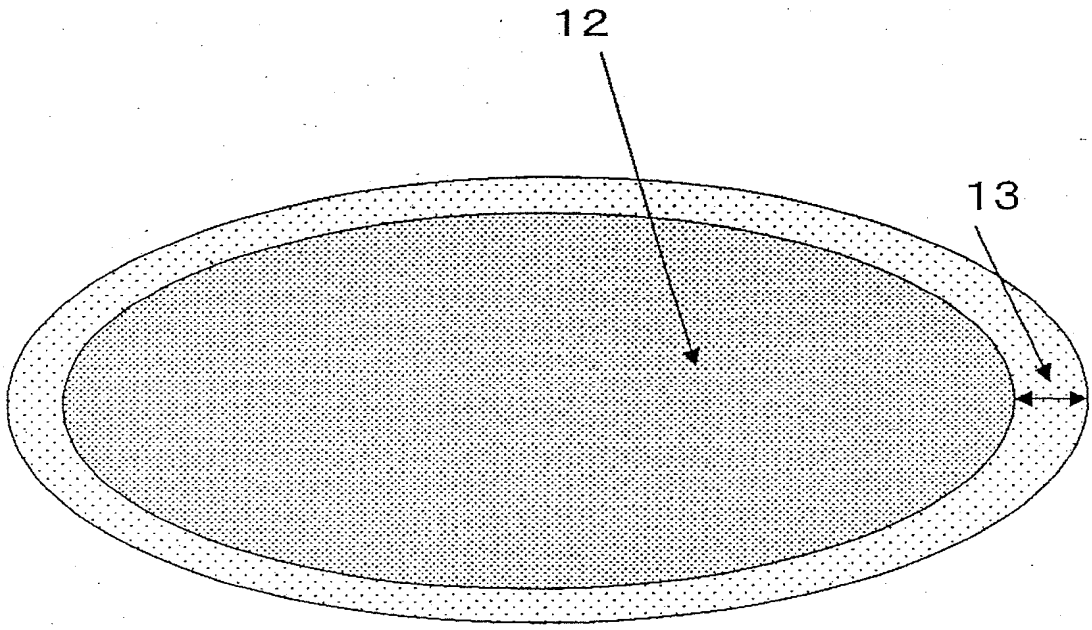

FIG. 3

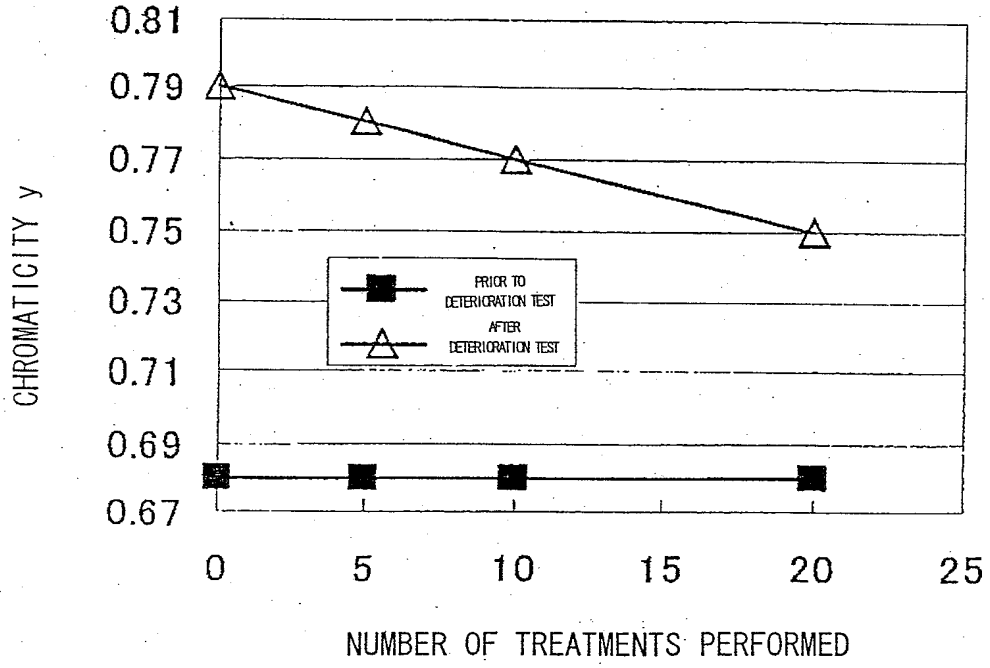
0.81
0.79
0.77
0.75
0.73
0.71
0.69
0.67
CHROMATICITY y
PRIOR TO DETERIORATION TEST
AFTER DETERIORATION TEST
0
5
10
15
20
25
NUMBER OF TREATMENTS PERFORMED

FIG. 4